

at the close of the month. As a whole the month was unfavorable and injurious to cereals and delayed the commencement of farm work by the continued low night temperatures freezing the ground and preventing its cultivation.

Oklahoma.—The temperature for March was about 3° above the normal; precipitation 1.34 of an inch below. At Buffalo, during a thunderstorm on the 10th, lightning set fire to the prairie 3 miles northeast of town and about 5,000 acres were burned over before the fire was put out by back firing. Another terrible fire extended both north and south of this town, by which many thousands of acres were burned over, feed, stacked hay, sorghum, and berries being destroyed.

Oregon.—Normal weather conditions prevailed during the current month, the mean temperature for the State being only 0.1° below the average, and 3.3° colder than the warmest March in the past six years. Precipitation, 0.10 inch below the normal. The sunshine was abundant throughout the State the first eighteen days, except the 11th and 12th. The days were quite warm and the nights not so cool as usual, so that the buds began to swell; even the several killing frosts did very little, if any, damage to the growing vegetation. Spring plowing and seeding were well advanced by the end of March and crops of all kinds in good condition. Lambing advancing rapidly and a large crop looked for. The date of general bloom of the fruit trees can safely be put down as March 25, though in some sections even earlier bloom prevailed.

Pennsylvania.—The average temperature for the month was 1.5° below the normal for the past seven years, and the average precipitation 1.26 inch below the normal for the same length of time. At the close of the month grain and grass appear to have wintered well, but all vegetation is backward, with but few signs of spring.

Rhode Island.—(See *New England*.)

South Carolina.—The current month was cooler than usual during the first half and warmer during the remainder, making the average temperature nearly normal. The rainfall was 1.25 inch in excess of the normal, and well distributed over the entire State. From the 20th to the end of the month but little or no rain fell. The excessive rainfall greatly interfered with farm work until this date, after which it progressed rapidly under favorable conditions.

South Dakota.—The first half of the month was cold and unseasonable, the remainder generally mild and more seasonable. Brisk to high winds prevailed much of the time, with a deficiency in precipitation over much of the State, rendering the top soil of plowed ground very dry and retarding seeding. The drought was succeeded generally by good rains and snows the last of the month, putting the ground in excellent condition for farm work.

Tennessee.—During the first three weeks of March abnormally low temperature and frequent rains retarded all farm work and prevented the growth of vegetation. The abnormally low temperatures and excessive rainfall of the first three weeks were followed by very warm weather in the last week, which caused vegetation to put forth rapidly

and practically opened the crop season of 1895. The prospects are still favorable for a large yield of fruits of all kinds.

Texas.—The temperature on an average for the State was 0.8° below the normal. The greatest deficiency was in the vicinity of Houston. The average precipitation was 0.62 inch below and not very well distributed. Farming operations are from one to two weeks late in comparison with past years' records, except cotton planting, which was apparently only five to eight days late at the close of the month. The crop prospects are good all over the State and the fruit trees are generally blooming nicely, with prospects for a good crop.

Utah.—The monthly mean temperature for the Territory was 5° below the normal; precipitation was also below. Two severe blizzards reported from Heber. Spring generally backward.

Vermont.—(See *New England*.)

Virginia.—Average monthly mean temperature for the current month 1.4° below the normal and precipitation about the normal for the State, being generally slightly above near the coast and least in the northern section. The prevailing rains and cool weather generally prevented farm work and preparation for spring crops until about and after the 25th, so that such work was thus thrown two or three weeks behind the average season. This was specially noticeable in the trucking sections. The generally cool temperature kept back the fruit bloom during the month, and thus increased the probability of a good fruit crop.

Washington.—The peculiar feature of the current month was the dry, warm, delightful weather of the first ten days, otherwise it was not an exceptionally warm month, the mean temperature being about the same as the normal for several years and the total rainfall not far below. In the western section the average temperature was lower than that of February, but in the eastern it was warmer. With the warm days at the beginning of the month the snow went off early and the farmers improved the chance to plow and prepare land for spring seeding, of which latter much was done. The heavy frosts of the 15th froze out considerable winter wheat, which had to be resown. There were no very severe gales, although the month was somewhat windy.

West Virginia.—The mean temperature for March was about 2° below the normal and the average rainfall about 0.25 inch below. Rain or snow fell at points within the State every day except the 30th and 31st.

Wisconsin.—The first half of the current month was unusually cold, with zero temperatures occurring at frequent intervals up to the 15th. The month was extremely dry, the average rainfall being 0.50 of an inch, or 1.5 inch less than the normal for March. Most of the precipitation occurred in the form of snow. The usual spring rains were missing, and, as a consequence, the lack of moisture was felt quite severely in some sections and retarded the thawing out of the soil.

Wyoming.—The mean temperature for the month was slightly below the March normal and the average amount of precipitation was considerably above the March normal. Grass starting and cottonwood trees beginning to bud.

STUDIES BY FORECAST OFFICIALS.

I.—LOWS NORTH OF IDAHO AND MONTANA.

By Prof. H. A. HAZEN (dated August 21, 1893).

The following is a report "on the probable effect of the occurrence during September of low pressure areas to the north of Idaho and Montana in determining the weather conditions in the Upper Mississippi Valley and Upper Lake region within the next thirty-six to forty-eight hours."

In the following statement a careful study has been made of the three-times-daily and twice-daily manuscript maps of the forecast division for the 16 Septembers from 1877 to 1892. In this report a small subscript figure indicates the map used, whether a. m. (1), p. m. (2), or night (3). Since 1888 there have been only two maps, a. m. (1) and p. m. (2).

DESCRIPTION OF THE MAPS.

1877.

- Sept. 6. Low in Montana; slow motion.
9. Moved to north Missouri.
9. In Illinois.
10. In Indiana; rain in Lower Lakes; none in upper.

1878.

- Sept. 7. Low in Dakota; slow motion.
9. Rain in Upper Lakes.
17. Low in Dakota.
19. Moved to Upper Lakes, with rain.

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- Sept. 23. Low in Montana.
24. In western Iowa; first rain in Upper Lakes.
1879.

- Sept. 8. Low near Montana; slow motion.
11. Moved to eastern Minnesota, with rain.
1880.

- Sept. 18-21. Marked low moving from north of Montana to north of Lakes; no rain. High to southeast, and later to south and southwest.
24-27. Another low above Lakes without rain.
1881.

- Sept. 8. In Montana.
9. Rain at St. Paul.
10. Rain, 1.31, La Crosse; 1.37, Omaha; 1.02, Dubuque.
13. Trough from Manitoba to Texas.
15. Formed or collected in a single storm in Indiana.
16. Western Wisconsin.
16. Northern Minnesota.
17. In Manitoba, moving a little northwest; heavy rain.
22. Northern Montana.
24. Minnesota; rain Upper Lakes; none lower.
25. In eastern Montana with trough south. General storm from Lakes to Texas with highs southeast and northwest.

Sept. 28₁. In Montana; moved slowly to the north of Upper Lakes.
30₁. No rain.

1882.

Sept. 10₁. Low in Montana; moving very slowly; no rain in Upper Lakes.

13₁. Low in Montana.

18₁. Reached Upper Lakes, where there was light rain.

1883.

Sept. 2₁. Low north of Montana.

3₁. Upper Lakes; no rain; moved north of Lakes with traces of rain only.

5₁. Low north of Montana.

6₁. Moved to eastern Dakota.

6₁. To southern Minnesota; rain in Upper Mississippi and Lakes.

8₁. North of Montana; very slow motion.

13₁. Trough from Manitoba to Texas; rain at St. Paul; did not develop.

14₁. North of Montana.

15₁. In northern Minnesota; light rain Upper Lakes.

17₁. North of Montana.

20₁. Trough from Minnesota to Texas; no rain.

25₁. North of Montana.

26₁. Lake Superior; no rain; high southeast.

1884.

Sept. 20₁. North of Montana.

21₁. Lake Superior; no rain.

21₁. Light rain rear of this storm.

26₁. North of Montana.

27₁. Formed trough with low in Kansas.

28₁. Merged in single low north of Lakes; rain from Lower Lakes east.

1885.

Sept. 1₁. North of Montana.

2₁. North of Lake Superior; light rain at St. Paul.

9₁. North of Idaho.

11₁. Trough from north of Montana to Colorado.

11₁. Developed in a storm in eastern Dakota; rain in Upper Mississippi.

12₁. Rain on Upper Lakes; low remained north of Dakota till 13th.

13₁. No rain; moved north of Lakes.

14₁. No rain.

19₁. In Montana.

20₁. North of Lakes; no rain.

21₁. North of Montana.

21₁. Upper Lakes; no rain.

22₁. North of Montana.

26₁. Upper Lakes; no rain.

27₁. North of Montana.

28₁. In northern Minnesota; 0.03, La Crosse.

1886.

Sept. 8₁. Low north of Montana.

9₁. In Manitoba.

9₁. Upper Lakes; rain.

1887.

Sept. 5₁. Low north of Montana (ill defined).

6₁. Over Lake Superior; light rain.

9₁. Low north of Montana.

12₁. Moved to Manitoba; rain on Upper Lakes.

25₁. Trough from Montana to Texas.

30₁. Most of rain due to Gulf cyclone.

1888.

Sept. 4₁. Low in Montana; moving slowly.

7₁. In Manitoba, with rain in Upper Lakes.

Sept. 11₁. North of Montana; slow motion.

15₁. Lake Superior.

15₁. Trough to Gulf which gives light rain.

25₁. North of Montana.

26₁. Lake Superior; light rain.

1889.

Sept. 2₁. North of Montana.

4₁. Trough from Minnesota to northern Texas; light scattered rain.

27₁. Disturbed region north of Montana.

29₁. Moved to Manitoba.

30₁. Sprinkle of rain southeast of low.

1890.

Sept. 1₁. Low in Nebraska.

4₁. Moved to Manitoba; light rain. No low to north of Idaho and Montana this month.

1891.

Sept. 9₁. Low in Montana.

12₁. Moved to Upper Lakes; light rain.

24₁. North of Montana; very slow.

27₁. In Dakota; sprinkle.

1892.

Sept. 8₁. Low north of Montana.

9₁. Trough from Dakota to Kansas; sprinkle.

22₁. Low north of Montana.

25₁. Moved to Upper Lakes, with light rain.

CONCLUSIONS.

The above facts lead to the following conclusions:

1. The motion of lows in the extreme northwest is very markedly affected by the position of high areas to the east and southeast. In general, this motion is remarkably slow, often requiring three, four, or more days to reach the Upper Mississippi Valley and Upper Lake region.

2. The amount of rain from well-defined lows in the extreme northwest is very small, probably not more than 5 per cent, or at most 10 per cent, of the total in the regions under consideration.

3. When this low forms a trough to the south, or when it moves first toward southeast and northeast, there is a good deal of rain usually. This motion is usually very slow.

4. It is not at all possible to forecast rain for the Upper Mississippi and Upper Lakes when a low appears in the extreme northwest. In general, if the motion is to the north of the Upper Lakes there will be no rain or only sprinkles. In some cases, with a strong north or northwest wind in the rear of a low, rain may be expected for the Upper Mississippi Valley, but this forecast must be made with great caution.

APPENDIX.

While investigating the above points it was decided to pay particular attention to the cause of abnormally dry or wet months.

The greatest dryness ensues when a well-marked high moves across the country from Dakota to Florida. A second cause of dryness is when a high area is rather permanent over any region. When a low area is followed by a high, if the after-winds are north or northwest, the tendency is toward a ragged clearing up, but if the after-wind is southwest there will be a quick clearing.

The heaviest rainfalls occur in connection with low areas coming from the Gulf and passing either directly over the region or to the south of it. The next heaviest are produced by troughs running nearly north and south and moving broadside on. In many cases heavy rains occur with a high area to the north and a disturbed region to the south but without a well-defined storm.

1877.

Dry.—Cause: 1st, highs moved from northwest to south-

east; 2d, a few highs moved slowly over the Lakes and swung around to the southeast on the Atlantic coast; 3d, lows starting in the west filled up before reaching the Lakes.

1878.

Wet.—Cause: 1st, much rain came from Gulf cyclones; 2d, there seemed to be also a locus of low areas in Minnesota.

1882.

Dry.—Due to the persistency of high areas over the Lake region and just a little south.

1886.

Wet.—Due, 1st, to a tendency to a permanent low area much disturbed in the north; 2d, most rain from troughs reaching across country to Texas and Gulf; 3d, there was a permanent and well-marked high area over the south Atlantic, and this may have assisted in giving rain in connection with the northern low disturbed region.

1888.

Dry.—Due to a passage of high after high over the Lakes and to a delay or sluggishness of highs as they moved alone.

1890.

Wet.—Due, 1st, to a disturbed region over the Lakes; 2d, some troughs; 3d, marked storms passed over the Lakes; 4th, there seemed a remarkable tendency to rain from north winds blowing out of highs but without any storm conditions to south.

1891.

Dry.—It is an interesting fact that the monthly mean isobars and wind directions for 1891 are almost exactly the same as for 1878 and 1890, both of which were very wet. Cause: 1st, wide extended highs moved over the Lakes and then to the south Atlantic States. The high in this region can hardly be said to have been permanent as in the wet September of 1886, but it was rather continually added to by fresh and dry highs coming from the north, i. e., the permanency was not sufficient to cause a strong flow of rather damp air from the Ocean or Gulf northward; 2d, there was a rather persistent low in the extreme northwest, from which, however, very few disturbed areas passed out, but these drew up the dry, warm air from the south; 3d, winds were mostly south and dry from dry highs.

It is not thought that there is much that is new in what has gone before. It is rather a collection of views which have been picked up from time to time but now brought together. It is impossible to lay down any but the broadest generalizations. Each map will need a treatment by itself, especially when any one map happens to show a combination of all or nearly all the points here assembled from a study of 1,290 maps.

II.—THE CONNECTION BETWEEN SUN SPOTS AND THE WEATHER.

By Prof. FRANK H. BIGELOW (written in July, 1895).

At the request of the Chief of the Weather Bureau an attempt was made in June, 1894, to take photographs of the sun spots on clear days. The only telescope available for this work was a 4-inch Clark visual objective, and, after some experiments, it was concluded that the pictures thus obtained were not sufficiently superior to screen diagrams to justify the time and labor of making them. Accordingly the series for the past year consists of hand-drawn diagrams of the approximate relative positions and sizes of the spots, the diameter of the image of the sun being 85 millimeters.

In order to determine whether there is any law that controls the production of spots on the several meridians of the sun, it is necessary to resort to a long series of observations. For this purpose the Carrington "Observations of the Spots on the Sun, November, 1853, to March, 1861, made at Redhill,"

the "Beobachtungen der Sonnenflecken zu Anklam und Potsdam, von G. Spörer, January, 1861, to December, 1879;" the "Photographic Results of the Greenwich Observatory, 1878 to 1891" (the last volume received), are available. The gap—1892 to June, 1894—has not been conveniently filled, though it can be done in due time. If spots have a tendency to form on certain solar meridians, then, in order to classify these as they appear, rotation after rotation, it is necessary to know the exact period of the rotation of the sun itself. In the October number, 1893, of *Astronomy and Astrophysics*, I published (page 9) my final result of the discussion of the periodic action in the European magnetic field, namely, 26.67928 days, and have in other places explained its connection with the sun's angular motion at the equator. This period has been tested, so that it can now be stated that the same periodic action was found in 1841 and other years up to 1895 and that this period, departing from the epoch June 12.22, 1887, does not fall short more than one-tenth of a day in fifty years. The spots have been grouped according to the accurate ephemeris instead of using the approximation 26.68.

Since the Carrington and Spörer series, and the Spörer and Greenwich series each overlap each other a little, it is possible to reduce the diagrams of Carrington and Spörer to the scale of the Greenwich series, so that a set of numbers, consistent, from 1854 to 1895, can be tabulated to show the amount of spotted areas that have occurred on the several days of the 26.68-day period in about forty years. A result that shows a definite tendency to group the spots on certain meridians becomes at once a test of the value of this period, and also points to many conclusions important in solar physics, terrestrial physics, and meteorology. For convenience the unit of area is the one hundred thousandth of the visible surface instead of one millionth. Each spot area is entered once for all, either as occurring on the central meridian or else at a date whose interval from this meridian can be computed from the available data. Hence, the tables show the total area of the sun-spot groups for forty years, arranged strictly in the 26.68-day period. The Northern and the Southern Hemispheres were kept separate throughout the compilation, and the final sums are wholly independent of each other.

The table and diagram (see Chart IX) give the sums for each of the four series specified and the sum of all, and also the curves displaying this last summation.

In plotting the curves for the Northern and the Southern Hemispheres it is seen that they are inverted curves of the same type. On comparing them with the magnetic curve derived from the European magnetic field (*Amer. Met. Journ.*, January, 1895), it is clear that the sun-spot curve for the Southern Hemisphere gives back the *direct* type, and the sun-spot curve for the Northern Hemisphere the *inverse* type of the terrestrial magnetic curve. This computation has been arranged throughout on the ephemeris with epoch June 12.22, 1887. The curves of the accompanying diagrams give the magnetic field direct for the Southern Hemisphere, and inverted for the Northern Hemisphere. The number and sequence of the maxima and minima, in spite of some looseness in the curves, point unmistakably to a fundamental physical process.

It will be remembered (*Amer. Journ. Sci.*, Dec., 1894,) that this same primary periodic curve was found in the temperatures of the American meteorological system, together with the phenomenon of inversion, for which no cause was assigned. The lines of force of the solar magnetic field as they pass through the earth have been fully explained (*Amer. Journ. Sci.*, Aug., 1895). The discussion of the sun-spot formations, herewith presented, makes it evident that during certain intervals the atmosphere of the earth is under the controlling influence of the southern magnetic hemisphere of the sun; and again, the transition being usually abrupt, it is under the